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THE MARINE FIRE SUPPORT TEAM AS A MODEL FOR DISTRIBUTED OPERATIONS ANALYSIS: REVIEW OF PRIOR ANALYSES, SUMMARY OF ONGOING RESEARCH, AND RECOMMENDATIONS FOR FUTURE WORK

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The emerging doctrine of distributed operations (DO) presents the Marine Corps with significant human performance challenges. Although it is an emerging doctrine, many key features of DO have been fairly well-established. Instead of tactical decisions being made at the command level they will increasingly be made by small unit leaders carrying out combat operations. Unlike traditional units, DO units will be capable of directly coordinating fire support from joint fire agencies to effectively respond to a broad range of threats. Sophisticated electronic communications will extend below the company level to small DO units to enable separation and coordination of interdependent tactical actions (Mattis, 2006). Due to their expanded role, leaders of DO units must possess a broad range of leadership and decision-making skills to effectively execute missions consistent with the commander?s intent. Many of these leadership and decision-making skills can be improved through interventions, such as training, assessment, classification, job-aiding, or equipment design. All of these interventions require extensive front-end analysis (e.g., job analysis, task analysis, user needs analysis) to facilitate implementation. The Marine fire support team (FiST) was selected as a DO unit proxy of small unit leadership and call-for-fire positions, to allow investigation into how best to identify, train and equip Marines to perform in these positions effectively. This report describes research completed during 2007, subsequent work currently underway, and recommendations for future work to support DO Marine manpower, personnel and training needs.

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ABSTRACT

The emerging doctrine of distributed operations (DO) presents the Marine Corps with significant human performance challenges. Although it is an emerging doctrine, many key features of DO have been fairly well-established. Instead of tactical decisions being made at the command level they will increasingly be made by small unit leaders carrying out combat operations. Unlike traditional units, DO units will be capable of directly coordinating fire support from joint fire agencies to effectively respond to a broad range of threats. Sophisticated electronic communications will extend below the company level to small DO units to enable separation and coordination of interdependent tactical actions (Mattis, 2006). Due to their expanded role, leaders of DO units must possess a broad range of leadership and decision-making skills to effectively execute missions consistent with the commander's intent. Many of these leadership and decision-making skills can be improved through interventions, such as training, assessment, classification, job-aiding, or equipment design. All of these interventions require extensive front-end analysis (e.g., job analysis, task analysis, user needs analysis) to facilitate implementation. Since DO is experimental and similarly qualified leaders are heavily engaged in the current global war on terrorism, this report focuses on related domains that are found in small units operating under conditions of relative autonomy as proxies for DO. Specifically, the Marine fire support team (FiST) was selected as a DO unit proxy of small unit leadership and call-for-fire positions, to allow investigation into how best to identify, train and equip Marines to perform in these positions effectively. This report describes research completed during 2007, subsequent work currently underway, and recommendations for future work to support DO Marine manpower, personnel and training needs.

BACKGROUND

Today's Marine faces enemy combatants who have adapted to exploit soft points in otherwise overpowering U.S. forces. The United States Marine Corps (USMC) is adjusting its warfighting doctrine to provide the flexibility to respond to these small asymmetric threats while maintaining military superiority over larger, more conventional, forces. Distributed Operations (DO) is an emerging USMC operational doctrine developed to meet these challenges by employing the coordination of interdependent tactical actions by small dispersed units. DO will be implemented through emerging command and control technologies that extend communications to smaller unit levels and through small unit leaders. Success of these units will require leaders who are highly skilled at tactical decision making. For a more comprehensive description of the concept of DO see http://www.mcwl.usmc.mil/SV/SV_DO.cfm#Articles. Implementation of DO will provide the US Marine Corps with the increased flexibility to efficiently respond to both asymmetric and symmetric threats. However, many challenges must be overcome before the concept can be realized.

Major challenges to the implementation of DO:

a. One challenge to the implementation of DO is ensuring effective decentralized execution or the devolution of decision making responsibility from higher echelons to small unit leaders (Hagee, 2005). Under the concept of DO, small unit leadership will gradually become the responsibility of NCOs. These NCOs will be required to possess knowledge, skills, abilities, and other characteristics (KSAOs) now required of Marine officers in traditional infantry units. These NCOs must understand DO tactics and be highly skilled at managing information in fast paced combat environments (Gilman, 2006). They must be able to effectively adjust to the quickly changing dynamics of the battlefield by making timely and accurate tactical decisions that support the overall mission objective without need for authorization (Gilman, 2006). Consequently, the success of DO will depend on the quality of these NCOs. The Marine Corps must ensure that NCOs chosen to lead DO units possess the ability to execute missions physically distributed throughout the battlespace. A rigorous assignment process and a focused comprehensive training regimen will be required to ensure that Marines chosen to lead DO units possess the KSAOs to excel in these positions (Corazo, 2005; Gilman, 2006).

b. A second challenge to implementation of DO is the requirement for future DO units to direct joint-fire agencies. Currently, this is a capability that exists no lower than the company-level. Distributed operations will generate a high demand for joint terminal attack controllers (JTAC) and forward observers (FOs; Carazo, 2005). A comprehensive assessment and training process should also be used to identify and train JTACs and FOs for assignment to DO units, or for assignment and training of incumbent DO unit members for these roles.

Potential Solution for DO Implementation:

A wide array of human performance improvement tools, such as personnel classification/assignment systems, and training programs are available to address challenges to the implementation of DO. However, the development of human performance improvement

tools requires front-end analysis (e.g., job analysis, task analysis, user needs analysis) to facilitate their design. Such front end analyses rely on the availability of subject matter experts (SMEs) to provide the information required. However, currently very few SMEs are available with operational DO experience. The one DO unit in existence is an experimental unit assigned to the Marine Corps Warfighting Lab (MCWL), where the concept of DO is being developed. The Naval Research Laboratory (NRL) conducted the only formal task analysis (TA) focused on the experimental DO unit at MCWL. The purpose of the TA was to evaluate and recommend appropriate communications equipment for DO units at, and below, the company-level (Coyne, Stripling, Pfluger, La Budde and Afergan, 2007). The need for a comprehensive task analysis of non-communications related DO topics remains unfulfilled. Due to the lack of operating DO units, existing operational domains that impose similar mental and physical demands must be identified to serve as proxies for DO positions. TAs performed on operational proxies can be used to direct the development of human performance improvement tools to support the emergence of DO. As the doctrine of DO takes form over the next several years, human-performance research must advance in tandem to maximize the warfighting effectiveness of Marines assigned to DO units.

The purpose of this report is to survey previous front-end analytic work pertaining to small unit leadership, decision-making, and call-for-fire duties. This information will be used to develop a personnel classification/assignment system that will identify NCOs who display the most potential to succeed in specific DO positions. The report will also recommend additional work to further develop the classification/assignment system.

CURRENT WORK

The Marine Fire Support Team (FiST) was selected to serve as an operational proxy for DO because it contains several positions of specific relevance to future DO units (e.g. a small unit leader and call-for-fire positions). FiST has been the subject of extensive task analysis to support the development of a simulation-based training program. Information derived from prior TAs will provide a springboard for this effort to establish how best to identify and train Marines to perform in two important DO positions. The majority of FiST positions are performed by commissioned officers, whereas, DO units will be composed mostly of NCOs. However, because NCOs manning DO units must perform functions traditionally performed by commissioned officers, TAs focused on officers in operational proxy positions must be used to establish the ideal mixture of KSAOs for NCOs assigned to DO positions.

The FiST is a company-level asset that functions to coordinate indirect fire agencies to support a maneuver element. The FiST generally consists of three or four principal members including: a FiST Lead (team leader), a forward air controller (FAC) or JTAC, and at least one forward observer (FO). The FiST Lead, an infantry officer, typically a 1st Lieutenant, is responsible for mission planning and execution to provide a maneuver element with supporting fires, in accordance with the commander's intent. The mission of the FiST Lead is cognitively demanding, requiring a comprehensive understanding of battlespace geometry, dynamic planning, situational awareness, and the ability to adjust to changing conditions under time pressure. These demands overlap significantly with those anticipated for NCOs leading future DO units, making the FiST Lead a logical proxy for the study of small-unit leadership and

decision-making. A comprehensive analysis of KSAOs associated with successful FiST leads will provide insight into qualities that are associated with a high probability of success among DO unit leaders.

A comprehensive analysis of FiST will also facilitate efforts to identify requisite KSAOs for call-for-fire positions, which will also be a requirement for future DO units. Lessons learned in the FiST domain will be generalized to the DO domain to inform research into assigning, training and equipping DO marines assigned call-for-fire responsibilities. The current FiST unit typically has three call-for-fire positions including the FAC, who functions in the same capacity as a JTAC, an artillery FO and a mortar FO. The FAC or JTAC, generally a Captain, is responsible for terminal control of fixed-wing and rotary-wing aircraft providing supporting fires. The artillery FO coordinates supporting fires from the artillery support unit; and a mortar FO coordinates supporting fires from mortar units. Often, the artillery and mortar FO responsibilities are performed by a single FO. Artillery FOs are artillery officers, typically at the rank of Captain. Mortar FOs are usually NCOs. All three of these positions are expected to be filled by NCOs in future DO units. TAs conducted on these operational positions will provide critical KSAOs to drive the development of classification/assignment tools. The classification/assignment tool will identify NCOs best suited for directing joint fire agencies to support future DO missions.

Existing FiST Analysis

The most comprehensive task analysis of FiST operations was conducted under the auspices of the Office of Naval Research Virtual Technologies and Environments (VIRTE) program, in support of the development of an experimental simulation-based training suite for FiST members and teams. In several unpublished reports, FiST individual and team-level task taxonomies and associated performance metrics derived from document reviews, SME interviews, observations and analyst ratings have been detailed (Design Interactive, 2006; Design Interactive, Anthrotronix, Inc. and Naval Postgraduate School, 2006). Task taxonomies and performance metrics were validated via SME feedback. These analyses also used ratings from human factors experts to identify and link a small number of higher-order team and individual KSAOs to each performance goal/metric for use in skill-based training. These performance metrics ultimately were embedded into an after-action review (AAR) module of a prototype trainer, which was undergoing evaluation at the time of this report. The TA report listed 29 tasks, mapped onto 8 mission-critical friction points. The 29 tasks were decomposed into a total of 181 subtasks. These tasks and subtasks correspond very closely to team-level tasks and individual-level tasks. For the research described in this special report, the subtasks were separated and defined by individual position. The artillery and mortar FO positions were treated as a single position in the Design Interactive (2006) TA, and that singularity was preserved in the current derived taxonomy. In future work, separate task taxonomies will be developed for the artillery and mortar FO positions.

DI et al. also developed several higher-order (multivariate) KSAOs to serve as team and individual-training objectives (Appendix A). While higher-order KSAOs may serve a useful function for individual and team-training applications, they lack the desirable psychometric

properties required for classification/assignment applications. Measurement of traits at the univariate, facet-level is desirable to disentangle sources of predictive variance during the test validation process. Univariate measures are likely to exhibit greater measurement reliability, which in turn affects maximum observed test validity. The goal of the current project is to expand upon prior FiST task analytic work. The expansion will include identification of facet-level (univariate) KSAOs to facilitate the development of the classification/assignment system for DO. During this process relationships between individual task performance and team performance will be identified. In addition, new task rating scales will be developed to broaden the scope of the analysis to new applications.

FiST Composite Mission Analysis (CMA) Template

CMA is an approach to job-task analysis that incorporates multiple levels of data collection and synthesis, across multiple levels of analysis and multiple organizational levels. This approach has multiple inter-related goals. One is to define job and mission tasks at the individual, team, and organizational levels to facilitate analyses at multiple organizational levels. Another primary goal is to identify linked tasks between organizational levels to determine how task performance at, for example, the individual team member level affects team performance. The CMA approach relies on subject-matter expert ratings to establish not only tasks and task linkages, but also to identify relevant KSAOs and to link them to the performance of relevant tasks, jobs and missions.

The FiST CMA will be composed of the following elements, as seen in Table 1.

Table 1. Composite Mission Analysis of Marine Fire Support Team (FiST)

A. TASKS

1. FiST team task taxonomy (as adapted from DI TA)
2. FiST Leader task taxonomy (as adapted from DI TA)
3. FAC task taxonomy (as adapted from DI TA)
4. Artillery FO task taxonomy (as adapted from DI TA)
5. Mortar FO task taxonomy (as adapted from DI TA)

B. PERFORMANCE METRICS

1. Team task performance metrics
2. Fist leader task performance metrics
3. FAC performance metrics
4. Artillery FO performance metrics
5. Mortar FO performance metrics

(note: B1 through 5 have already been developed by DI under the VIRTE program and have been SME validated)

C. KNOWLEDGE, SKILLS, ABILITIES, AND OTHER CHARACTERISTICS (KSAO)

1. Team KSAOs. They will be developed and linked (rated by relevance) to team tasks via SME interviews/questionnaires.

2. Individual-level KSAOs. A facet-level KSAO taxonomy consisting of 78 cognitive, non-cognitive, physiological, sensory and physical KSAOs was developed by Human Performance Architects for use in other classification/assignment initiatives (see appendix B). The decision to use such a large number of preliminary KSAOs was made to ensure essential traits were not overlooked during the job-task analytic process, and to facilitate unambiguous measurement by focusing to the greatest extent possible on univariate psychological constructs.

D. TASK RATING SCALES

1. Task criticality
2. Task frequency
3. Task difficulty
4. Task difficulty to learn
5. Task susceptibility to fatigue
6. Task importance (derived from importance and frequency)
7. Others, as needed

E. LINKAGES

1. Task-task (across organizational levels)
2. Task-performance
3. KSAO-task
4. KSAO-task-performance

FiST KSAO Analysis: Preliminary Results

A preliminary analysis was performed to reduce the number of KSAOs under consideration prior to soliciting SME ratings and to provide an empirical basis for the development of a initial battery of tests for use in the prediction of FiST team member job performance. The ultimate goal is to develop a validated battery for DO small-unit leader classification and assignment applications. As the first step in the development of the KSAO component of the composite mission analysis framework for DO, researcher ratings for 78 facet-level KSAOs across cognitive, non-cognitive, physical, psychomotor, and sensory domains were collected, as listed in appendix B. Researcher ratings were obtained for three FiST positions: FiST Leader, FAC, and FO. Two researchers familiar with FiST operations provided ratings of KSAO criticality to job performance using a 5-point Likert-type rating scale. Raters were provided with FiST Leader, FAC, and FO task taxonomies to use for reference while making their ratings. .

Analysis of the ratings of the three FiST positions revealed high inter-rater reliability, ranging from r = .63 for FO to r = .68 for FiST Leader. A mean rating of 4.0 (1 = KSAO unrelated to successful job performance, 2 = KSAO weakly related to job performance, 3 = KSAO helpful for successful job performance, 4 = KSAO important for successful job performance, 5 = KSAO critical for successful job performance) or better was used as the criterion for continuation of KSAOs into the next phase of the project (collection of SME ratings and potential inclusion in preliminary assessment test battery). Due to the complex nature of FiST operations, and the diverse demands of all positions within the FiST, it is perhaps not surprising that a majority of KSAOs exceeded the minimum inclusion criteria for all positions (see appendices C-E). Table 2 provides a list of KSAOs exceeding the minimum criteria for FiST Leader, FAC, and FO positions. In FY 08, KSAOs exceeding the minimum criteria will be validated by SMEs for each FiST position.

Table2. KSAOs exceeding minimum inclusion criteria (rating of 4.0) for FiST Leader, FAC and FO positions

Fist Lead		
5.0	**4.5**	**4.0**
Critical Thinking Skills Decision Making Skills Oral Comprehension Oral Expression Spatial Orientation Map Reading Concentration/Selective Attention Attention Allocation and Control Task Prioritization Working Memory Confidence Teamwork Skills Leadership Skills Leadership Motivation Assertiveness Adaptability Emotional Control/Stability Stress Tolerance/ Handling Crisis/ Emergency Situations Disengagement Time Management Skills Planning Skills	Mental Math Information Management Skills Systems Comprehension Problem Solving Skills Mastery Orientation Dependability Deliberation Organization Skills Attention to Detail Safety Consciousness Visual Acuity Depth Perception	Mathematical Ability Numerical Reasoning Reasoning Skills Mental Rotation Learning Ability Long-term Memory Work Motivation Initiative Self-discipline Interpersonal Skills Perceptual Speed and Accuracy Rule Abiding Accountability Reaction Time Hearing
Forward Air Controller/Joint Terminal Attack Controller		
5.0	**4.5**	**4.0**
Mental Math	Mathematical Ability	Numerical Reasoning

Decision Making Skills Oral Comprehension Oral Expression Spatial Orientation Map Reading Concentration/Selective Attention Attention Allocation and Control Task Prioritization Working Memory Teamwork Skills Adaptability Stress Tolerance Handling Crisis/Emergency Situations Disengagement Time Management Skills Planning Skills Visual Acuity	Information Management Skills Problem Solving Skills Mental Rotation Emotional Control/Stability Listening Skills Organization Skills Attention to Detail	Systems Comprehension Critical Thinking Skills Reasoning Skills Confidence Dependability Self-discipline Accountability Deliberation Safety Consciousness Perceptual Speed and Accuracy Response Selection Hearing Depth Perception
Forward Observer (combined Artillery/Mortar)		
5.0	**4.5**	**4.0**
Mental Math Oral Comprehension Oral Expression Spatial Orientation Map Reading Concentration/Selective Attention Attention Allocation and Control Task Prioritization Working Memory Teamwork Skills Adaptability Emotional Control/Stability Stress Tolerance Handling Crisis/Emergency Situations Disengagement Planning Skills Attention to Detail Visual Acuity Depth Perception	Numerical Reasoning Information Management Skills Critical Thinking Skills Problem Solving Skills Decision Making Skills Mental Rotation Accountability Deliberation Listening Skills Organization Skills Time Management Skills	Mathematical Ability Reasoning Skills Initiative Confidence Dependability Self-discipline Safety Consciousness Perceptual Speed and Accuracy Response Selection

RECOMENDATIONS FOR FUTURE TASK ANALYTIC WORK

During combat operations, the ability to make fast and accurate decisions often defines the difference between mission success and failure. Commissioned infantry officers are extensively trained to be adept tactical decision makers. However, DO will require tactical decisions to be made by NCOs who may lack extensive training in tactical decision making. Focused, domain specific training must be developed to bring the tactical decision making skills of NCOs closer to that of commissioned officers. This demand may be partially addressed through the use of high-fidelity simulation of combat environments. Such simulations can be used to provide NCOs with extensive repeated exposure to relevant combat environments. However, merely practicing technical skills through simulation will not improve decision making ability. Work must be done to populate simulations with real-world domain-specific decision making scenarios that possess high psychological fidelity with the actual demands imposed by the job being trained. Efforts must also be made to develop methods to quantify the accuracy and effectiveness of decisions. Valid quantification of the accuracy and effectiveness of decision making will provide performance feedback to trainees significantly facilitating the development of expert decision making. Valid quantification of decision making will also provide an assessment of operational readiness for small unit leaders and identification of additional individual training needs.

Quantification of effective decision making can best be accomplished through a cognitive task analysis (CTA) conducted on specific DO domains. This first requires identification of critical information that experts utilize to drive their decision making. The critical decision method (CDM), outlined by Hoffman, Crandall, & Shadbolt, (1998), is a tool well suited for decision making analysis. First, the CDM specifies an operational timeline and identifies points within the timeline where important decisions are made (decision points). Second, the CDM identifies the critical information within the operational environment that experts rely on to accurately guide decision making (cue inventories). Often critical information comes in the form of pattern recognition strategies or environmental cues that are primarily perceptual in nature. For example, firefighters often use flame color and smoke movements to determine the origin and intensity of a building fire and base their plan of action accordingly (Klein et al., 1986). The CDM allows one to develop a comprehensive taxonomy of cue inventories around each decision point. Cue inventories are lists of key environmental cues associated with a decision point along with detailed descriptions of how the information should be interpreted and utilized. In the aforementioned firefighting example, key perceptual cues included flame color and smoke movement. Information delineated through the CDM can be presented in the form of a decision tree to comprehensively guide trainees through common decision points they are likely to encounter while in operational settings. Decision trees developed through the CDM can be studied and practiced through high-fidelity simulations to provide repeated exposure to common situations faced on-the-job in sometime hazardous environments. Information delineated from the CDM can also be used to help prepare trainees for uncommon or rare scenarios they may encounter on the job.

As noted in the previous paragraph cues used to drive expert decision making are often perceptual in nature. Such as, among firefighters where the detection of smoke movement and flame color represent perceptual abilities imperative for expert performance. The CDM will inform classification/assignment systems and training programs of important perceptual skills that traditional task analyses overlook. Information acquired through the CDM will allow

classification/assignment systems to consider important domain specific perceptual ability in addition to other KSAOs during the classification/assignment process. Likewise, the CDM will inform the training community of important perceptual learning opportunity that will facilitate the development of expertise within specific DO domains.

CONCLUSIONS

Distributed operations will present the Marine Corps with significant human factors challenges. By validating and implementing human performance improvement interventions across a range of human systems integration (HSI) domains, many of the inherent risks of this new doctrine can be mitigated. Research proxies are useful when operational units or personnel are not available. The use of Marine FiST operations as a research proxy for DO is appropriate in this study at several levels. The FiST is a small unit which typically operates remotely from other units and from the command structure. Its primary function is the coordination of fires in support of the mission objectives. Marines assigned to DO units, including unit leaders, will be increasingly selected from enlisted personnel, whereas FiST personnel include officers and enlisted Marines. However, the similarity of operations envisioned for DO infantry platoons and squads, makes FiST a valid domain from which to generalize lessons-learned concerning manpower, personnel and training. The significant cognitive information processing requirements involved in problem solving and decision-making in a dynamic, high-stress environment, make questions concerning approaches to manning and training of DO units critically important. Effective personnel assessment systems can ensure the right Marines are performing the right jobs, and are receiving the right training at the right time. Composite mission analysis will provide the baseline task and KSAO data to underpin such assessment tools, and the validation of such tools. The validation of such tools will provide the Marine Corps an empirical foundation for developing effective personnel assignment and training tools for DO.

REFERENCES

Anderson, R.R. (2001). Task force fire support evolution: FIST (fire support team) employment. *Field Artillery, Sep/Oct, 2001*, 29-31.

Babilot, M. (2005). Comparison of a distributed operations force to a traditional force in urban combat. Naval Postgraduate School thesis, September, 2005.

Bain, M.D. (2005). Supporting a Marine Corps distributed operations platoon: A quantitative analysis. Naval Postgraduate School thesis, September, 2005.

Carazo, M.A. (2005). Distributed operations: The evolution of warfare in the 21st century. Naval War College thesis XBNWC/JMO, 14 February, 2005.

Chamberlain, R.M. (2004). 101st FIST (fire support team) platoon in SOSO (stability and support operations): Lessons learned from CMO. *Field Artillery, Sep/Oct, 2004*, 33-35.

Coyne, J.T., Stripling, R., Pfluger, K.C., La Budde, Z. & Afergan, D. (2007). Company and below command and control information exchange study. Naval Research Laboratory report number NRL/FR/5511-07-10,154 dated 22 October 2007.

Design Interactive (2006). Fire support team (FiST): Task analysis, performance metrics and scenario manipulation variable. Unpublished interim technical report, May 2006.

Design Interactive, Inc., AnthroTronix, Inc. & Naval Postgraduate School (2006). Fire support team (FiST) task analysis (TA) surrounding 8 friction points. VIRTE Demo 3 TEE VPT. Unpublished report, V8, June 2006.

Erdie, P.B. (2005). The implications of distributed operations. *Marine Corps Gazette*, 89(12), *December, 2005*, 33.

Flynn, D.S. (2003). Transforming the FiST for the 21st century. *Field Artillery, Mar/Apr, 2003*, 20-21.

Frey, J.W. (2006). What does distributed operations mean for joint air fire support? Naval War College thesis XBNWC/JMO, 13 February, 2006.

Gilman, B.L. (2006). Distributed operations: Translating tactical capabilities into operational effects. Naval War College thesis XBNWC/JMO, 13 February, 2006.

Gividen, G.M. & Levine, J.M. (1984). The Fire Support Team Vehicle (FIST-V) System: An analysis of human factors, training, safety and related considerations. Army Research Institute Report number ARI-RN-84-141. December, 1984.

Glaros, G.E. (2005). WolfPAC: Exploiting distributed operations. *Proceedings of the United States Naval Institute, 131*(2), *February, 2005*, 42-45.

Goulding, V.J. (2005). Distributed operations: Naval transformation starting at the squad level. *Marine Corps Gazette, 89*(4), *April, 2005*, 46-48.

Goulding, V.J. (2006). Just DO it: Distributed operations in the Marine Corps. *Proceedings of the United States Naval Institute*. *132*(11), *November, 2006*, 32-25.

Grynovicki, J.O. & Smith, J.H. (1985). Experimental design and analysis for the FIST (Fire Support Team) force development testing and experimentation II. Army Ballistic Research Lab, Aberdeen Proving Ground, Md. Report number BRL-MR-3474. October, 1985.

Hanlon, E. (2004). Distributed operations: The time is now. *Marine Corps Gazette, 88*(7), *July, 2004*, 37-41.

Henderson, A.M. (2006). Command, cooperation, and control for joint distributed operations. Naval War College thesis, 13 February, 2006.

Hoffman, R.R., Crandall, C., & Shadbolt, N. (1998). Use of the critical decision method to elicit expert knowledge: A case study. Human Factors, 40(2), 254-276.

Holzer, R.D. (2005). WolfPAC: Distributed operations experiment. *Officer, 81*(1), *Jan/Feb, 2005*, 39-40.

Klein, G.A., Calderwood, R., & Clinton-Cirocco, A. (1986). Rapid decision making on the fire ground. *Proceedings of the Human Factors Society 30th Annual Meeting*, 576-580.

Lackey, S. (2004). Initial look at distributed operations reveals potential and problems. *Sea Power, 47*(12), 34-35.

MacIntyre, D.J. (2005). More on distributed operations. *Marine Corps Gazette*, *89*(7), *July, 2005*, 41-43.

Mattis, J.N. (2006). Distributed Operations. Briefing to Assistant Secretary of the Navy (RD&A), 23 June 2006, SPAWAR Systems Command, San Diego, CA.

Nizolak, J.P. (1992). FIST (fire support team) training: Tropic Lightning (25th Infantry Division Artillery) style. *Field Artillery, October, 1992*, 50-53.

Reynolds, R.W. (2005). Intelligence support to distributed operations. *Marine Corps Gazette*, *89*(12), *December, 2005*, 13-15.

Schmidle, R.E. (2004). Distributed operations: From the sea. *Marine Corps Gazette, 88*(7), *July, 2004*, 37-41.

Sims, J.N. (2003). The Marine Corps FiST: An interorganizational analysis of the Fire Support Team and its environment. Naval Postgraduate School thesis, December, 2003.

Sommerer, J.C. & Mattis, J.N. (2006). Distributed Operations. Naval Research Advisory Committee, Arlington, VA. Report XBSSC/SD, dated 23 June 2006.

Sousa, A.G. (2004). FiST up! Task organizing fire support teams for maximum flexibility in mechanized operations. *Marine Corps Gazette*, *88*(1), 42-44.

Woeltjen, D.A. (1996). Operational maneuver from the sea and the Marine FiST. *Marine Corps Gazette, April, 1996*, 18-20.

Appendix A. 14 Team and individual Knowledge, Skills, Abilities, and Other Characteristics (KSAO; "training objectives") developed for simulation-based Fire Support Team (FiST) trainer (Design Interactive, 2006).

Team Training Objectives

1. Team SA (threat/friendly awareness)
2. Team SA (Timeline awareness)
3. Adaptive decision making (conflict resolution)
4. Adaptive decision making (asset allocation)
5. Coordination (mutual performance monitoring)
6. Coordination (information exchange)
7. Coordination (communication)
8. Leadership (initiative)
9. Leadership (guidance)

Individual Training Objectives

1. Decision making
2. Spatial knowledge
3. Procedural knowledge
4. Perceptual knowledge
5. Team coordination

Appendix B. Preliminary Knowledge, Skills, Abilities, and Other Characteristics (KSAO) taxonomy for composite mission analysis and assessment/classification system development

Cognitive KSAOs

1.0 Mathematical Ability

1.1 Mathematical Ability - To add, subtract, multiply, and divide accurately.

1.2 Mental Math - To perform mathematical operations in one's head quickly and accurately.

1.3 Numerical Reasoning - To reason through math problems to determine the operations that can be performed and possible solutions; to apply mathematical formulas to problems.

2.0 Problem Solving/Reasoning Skills

2.1 Information Management Skills - To perform research and gather information necessary to solve specific problems; to identify and locate important sources of information (for example, technical manuals).

2.2 Systems Comprehension - To understand a system as a whole and the relationships among its components; to anticipate how changes in one component will affect the system as a whole.

2.3 Technical Troubleshooting - To use technical information to identify the source of a problem and potential solutions.

2.4 Critical Thinking Skills - To analyze the strengths and weaknesses of specific actions or decisions.

2.5 Reasoning Skills - To apply rules to come up with logical answers to problems; to combine separate pieces of information to form general rules or conclusions; to recognize patterns or trends and anticipate outcomes.

2.6 Problem Solving Skills - To recognize problems, their potential causes and solutions, and when they are likely to occur; to create effective and innovative solutions to problems.

2.7 Decision Making Skills - To make effective, confident decisions in a timely manner; to use sound, informed reasoning and avoid bias when making decisions.

3.0 Communication Skills

3.1 Oral Comprehension - To understand spoken English words and sentences (for example, information, ideas, or instructions).

3.2 Written Comprehension - To read and understand written English words and sentences.

3.3 Oral Expression - To speak English words or sentences so others will understand; to express information or ideas clearly.

3.4 Written Expression - To write English words or sentences so others will understand; to spell correctly; to write clearly and use language appropriate for the audience.

***4.0* Spatial and Navigation Skills**

4.1 Navigation Skills - To effectively navigate through an unfamiliar area to a desired location.

4.2 Spatial Orientation - To know one's location in relation to the environment; to maintain directional orientation when navigating an unfamiliar area; to accurately estimate direction or location after traveling for a certain amount of time.

4.3 Spatial Visualization - To form a mental image of a pattern or figure; to visualize how an object would look after certain changes are made (for example, when it is moved around or when its parts are rearranged).

4.4 Mental Rotation - To accurately rotate an object (for example, a map) in one's imagination while maintaining an accurate sense of direction.

4.5 Map Reading - To understand a visual representation of an area; to use information from a map to aid in navigation.

***5.0* Mechanical Abilities**

5.1 Mechanical Comprehension - To understand how machines, tools, and mechanical equipment work; to understand how physical forces affect mechanical components.

***6.0* Multitasking and Attentional Skills**

6.1 Concentration/Selective Attention - To maintain high levels of performance on a task in distracting or repetitive conditions; to maintain focus despite interruptions.

6.2 Attention Allocation and Control - To flexibly switch attention across different tasks; to attend to multiple, potentially conflicting sources of information.

6.3 Task Prioritization - To perform multiple tasks in order of their importance; to direct attention to tasks when they change priorities (e.g., emergencies).

7.0 Learning and Memory Skills

7.1 Learning Ability - To be willing and able to acquire new skills quickly and easily; to quickly understand new concepts, ideas, or facts.

7.2 Long-term Memory - To retain and recall information (for example, words, numbers, pictures, and procedures) after long time periods.

7.3 Working Memory - To hold information in memory while processing other information.

Noncognitive KSAOs

8.0 Motivation

8.1 Work Motivation - To take a genuine interest in work tasks; to be willing to go above and beyond normal role duties; to be hard-working and ambitious.

8.2 Achievement Motivation - To seek out difficult and demanding tasks; to show extra effort and persistence when striving to meet work goals; to strive to do the best job possible.

8.3 Initiative - To initiate difficult tasks without excessive procrastination; to work independently and accomplish tasks without constant supervision; to take personal responsibility for completing work tasks.

9.0 Development Skills

9.1 Goal Setting - To set and strive towards challenging, realistic work goals; to adjust goals based on performance feedback.

9.2 Mastery Orientation - To seek out opportunities to acquire new skills and knowledge; to seek and use feedback to improve performance; to view performance errors as opportunities for self-improvement.

9.3 Confidence - To believe that one is capable of performing tasks in a wide variety of situations; to have confidence in one's skills and abilities.

10.0 Conscientiousness

10.1 Dependability - To be responsible, reliable, and punctual; to follow through on commitments.

10.2 Rule Abiding - To respect authority; to follow instructions and orders; to adhere to military rules, standards, and procedures.

10.3 Self-Discipline - To perform difficult, repetitive, or boring tasks while avoiding distractions or alternate activities.

10.4 Accountability - To consider oneself responsible for one's actions; to take corrective actions after making a mistake.

10.5 Deliberation - To be careful, thoughtful, and calculating when planning actions; to avoid impulsive actions; to imagine the possible outcomes of one's actions before acting.

10.6 Integrity - To be honest and trustworthy; to act according to high moral and ethical standards.

***11.0* Social/Interpersonal Skills**

11.1 Interpersonal Skills - To get along and interact effectively with a variety of people; to be tactful and diplomatic; to build and maintain effective working relationships with others.

11.2 Social Insight - To act appropriately in various social situations; to understand behaviors in the social environment in which they occur.

11.3 Agreeableness - To avoid interpersonal conflicts; to reach solutions to problems in a cooperative manner; to avoid upsetting others.

11.4 Social Closeness - To maintain close personal relationships; to be sociable and outgoing.

11.5 Listening Skills - To actively listen to and understand others; to attend to verbal and nonverbal cues (for example, body language, eye contact).

11.6 Teamwork Skills - To coordinate with others in a team setting to accomplish group goals; to assist team members who are overwhelmed; to offer and receive feedback.

11.7 Leadership Skills - To persuade and influence others to do perform specific actions; to act as a role model for others; to offer instruction and feedback to others as part of a team.

11.8 Assertiveness - To take charge and make decisions; to be persuasive, influential, and direct when dealing with others.

***12.0* Coping with Stress and Emergencies**

12.1 Adaptability - To adjust easily to changing situations or unexpected events; to flexibly change one's actions in response to changing task priorities.

12.2 Emotional Control/Stability - To control one's emotions in stressful situations; to avoid feelings of anxiety, insecurity, depression, or worry.

12.3 Stress Tolerance - To perform effectively under high workload, time pressure, or other stressful situations; to effectively handle stress under demanding situations.

12.4 Handling Crisis/Emergency Situations - To remain calm, analyze the situation, act appropriately, and make quick, accurate decisions in emergency situations.

12.5 Disengagement - To avoid disruptive thoughts after making an error; to quickly refocus attention on a task after a disturbing situation.

***13.0* Sensation Seeking**

13.1 Energy - To feel excitable and energetic; to show enthusiasm when performing work activities.

13.2 Adventure Seeking - To prefer tasks that may involve danger or risks (for example, high speeds); to avoid boring or routine activities.

***14.0* Planning and Organizing Skills**

14.1 Organization Skills - To schedule and organize one's work activities, materials, tools, and equipment in order to complete tasks efficiently; to keep one's work space neat and tidy.

14.2 Time Management Skills - To manage one's own time and the time of others to accomplish work goals.

14.3 Planning Skills - To carefully plan out the sequence of actions needed to meet short- and long-term work goals.

14.4 Attention to Detail - To pay close attention to the details of one's work; to ensure work is accurate and complete; to carefully review and scrutinize one's work.

14.5 Safety Consciousness - To be aware of safety hazards; to take steps to protect oneself and others from harm; to avoid risky behavior that could lead to accidents.

Physical, Perceptual, and Psychomotor KSAOs

15.0 Perceptual and Psychomotor Abilities

15.1 Pattern Recognition - To identify or detect a known pattern (for example, a numerical code); to combine and organize different pieces of information into a meaningful pattern quickly.

15.2 Perceptual Speed and Accuracy - To perceive or compare information (for example, letters, numbers, symbols, or patterns) quickly and accurately; to notice or compare details about things quickly and accurately.

15.3 Response Selection - To choose between two or more possible responses quickly and accurately when two or more different signals are given.

15.4 Control Precision - To control the motion of a machine, vehicle, or piece of equipment (for example, joystick or yoke) quickly and accurately; to make fine, precise movements or adjustments.

16.0 Sensory Perceptual Abilities

16.1 Visual Acuity - To accurately discriminate details of near or distant objects or objects near the edge of the visual field; to see under low light conditions.

16.2 Hearing - To detect and discriminate among sounds that vary in pitch or loudness.

16.3 Smell - To identify odors and their possible sources.

16.4 Touch - To feel heat, vibration, or textures; to feel differences or changes in heat, vibration, or textures.

16.5 Color Discrimination - To discriminate between different colors and levels of brightness or shades of the same color.

16.6 Auditory Attention/Localization - To focus on a sound in the presence of other distracting and irrelevant auditory stimuli; to tell the direction from which a sound came.

16.7 Depth Perception - To judge the distance of an object from an observer; to judge the relative distance of multiple objects from an observer.

17.0 **Physical and Psychomotor Abilities**

17.1 Manual Dexterity - To make skillful, coordinated movements of the hands; to grasp, place, move, or assemble objects using hand movements.

17.2 Multilimb Coordination - To coordinate the movements of the body or limbs.

17.3 Hand-eye Coordination - To make precise, coordinated movements based on visual information.

17.4 Reaction Time - To respond quickly and accurately to one signal with a manual (hand or foot) or verbal response.

17.5 Static Strength – The ability to exert maximum muscle force to lift, push, pull, or carry objects

17.6 Explosive Strength – The ability to use short bursts of muscle force to propel oneself (as in jumping or sprinting), or to throw an object

17.7 Dynamic Strength – The ability to exert muscle force repeatedly or continuously over time.

17.8 Trunk Strength – The ability to use one's abdominal or lower back muscles to support part of the body repeatedly or continuously

17.9 Stamina/endurance – The ability to exert oneself physically over long periods of time.

Appendix C. Fire Support Team (FiST) Leader Knowledge, Skills, Abilities, and Other Characteristic (KSAO) Ratings

KSAO	Rater 1	Rater 2	Mean rating
Map Reading - To understand a visual representation of an area; to use information from a map to aid in navigation.	5	5	5
Critical Thinking Skills - To analyze the strengths and weaknesses of specific actions or decisions.	5	5	5
Decision Making Skills - To make effective, confident decisions in a timely manner; to use sound, informed reasoning and avoid bias when making decisions.	5	5	5
Oral Comprehension - To understand spoken English words and sentences (for example, information, ideas, or instructions).	5	5	5
Oral Expression - To speak English words or sentences so others will understand; to express information or ideas clearly.	5	5	5
Spatial Orientation - To know one's location in relation to the environment; to maintain directional orientation when navigating an unfamiliar area; to accurately estimate direction or location after traveling for a certain amount of time.	5	5	5
Concentration/Selective Attention - To maintain high levels of performance on a task in distracting or repetitive conditions; to maintain focus despite interruptions.	5	5	5
Attention Allocation and Control - To flexibly switch attention across different tasks; to attend to multiple, potentially conflicting sources of information.	5	5	5
Task Prioritization - To perform multiple tasks in order of their importance; to direct attention to tasks when they change priorities (e.g., emergencies).	5	5	5
Working Memory - To hold information in memory while processing other information	5	5	5
Confidence - To believe that one is capable of performing tasks in a wide variety of situations; to have confidence in one's skills and abilities.	5	5	5
Teamwork Skills - To coordinate with others in a team setting to accomplish group goals; to assist team members who are overwhelmed; to offer and receive feedback.	5	5	5
Leadership Skills - To persuade and influence others to do perform specific actions; to act as a role model for others; to offer instruction and feedback to others as part of a team.	5	5	5

Leadership Motivation - To be motivated to assume leadership roles and responsibilities, and to maintain such motivation in persistence and intensity over time	5	5	5
Assertiveness - To take charge and make decisions; to be persuasive, influential, and direct when dealing with others	5	5	5
Adaptability - To adjust easily to changing situations or unexpected events; to flexibly change one's actions in response to changing task priorities.	5	5	5
Emotional Control/Stability - To control one's emotions in stressful situations; to avoid feelings of anxiety, insecurity, depression, or worry.	5	5	5
Stress Tolerance - To perform effectively under high workload, time pressure, or other stressful situations; to effectively handle stress under demanding situations.	5	5	5
Handling Crisis/Emergency Situations - To remain calm, analyze the situation, act appropriately, and make quick, accurate decisions in emergency situations.	5	5	5
Disengagement - To avoid disruptive thoughts after making an error; to quickly refocus attention on a task after a disturbing situation.	5	5	5
Time Management Skills - To manage one's own time and the time of others to accomplish work goals.	5	5	5
Planning Skills - To carefully plan out the sequence of actions needed to meet short- and long-term work goals.	5	5	5
Mental Math - To perform mathematical operations in one's head quickly and accurately.	5	4	4.5
Information Management Skills - To perform research and gather information necessary to solve specific problems; to identify and locate important sources of information (for example, technical manuals).	4	5	4.5
Systems Comprehension - To understand a system as a whole and the relationships among its components; to anticipate how changes in one component will affect the system as a whole.	4	5	4.5
Problem Solving Skills - To recognize problems, their potential causes and solutions, and when they are likely to occur; to create effective and innovative solutions to problems.	5	4	4.5
Mastery Orientation - To seek out opportunities to acquire new skills and knowledge; to seek and use feedback to improve performance; to view performance errors as opportunities for self-improvement.	5	4	4.5
Dependability - To be responsible, reliable, and punctual; to follow through on commitments.	4	5	4.5
Deliberation - To be careful, thoughtful, and calculating when planning actions; to avoid impulsive actions; to imagine the possible outcomes of one's actions before acting.	4	5	4.5

Organization Skills - To schedule and organize one's work activities, materials, tools, and equipment in order to complete tasks efficiently; to keep one's work space neat and tidy.	4	5	4.5
Attention to Detail - To pay close attention to the details of one's work; to ensure work is accurate and complete; to carefully review and scrutinize one's work.	5	4	4.5
Safety Consciousness - To be aware of safety hazards; to take steps to protect oneself and others from harm; to avoid risky behavior that could lead to accidents.	4	5	4.5
Visual Acuity - To accurately discriminate details of near or distant objects or objects near the edge of the visual field; to see under low light conditions.	4	5	4.5
Depth Perception - To judge the distance of an object from an observer; to judge the relative distance of multiple objects from an observer.	4	5	4.5
Mathematical Ability - To add, subtract, multiply, and divide accurately.	4	4	4
Numerical Reasoning - To reason through math problems to determine the operations that can be performed and possible solutions; to apply mathematical formulas to problems.	4	4	4
Reasoning Skills - To apply rules to come up with logical answers to problems; to combine separate pieces of information to form general rules or conclusions; to recognize patterns or trends and anticipate outcomes.	4	4	4
Mental Rotation - To accurately rotate an object (for example, a map) in one's imagination while maintaining an accurate sense of direction.	3	5	4
Learning Ability - To be willing and able to acquire new skills quickly and easily; to quickly understand new concepts, ideas, or facts.	4	4	4
Long-term Memory - To retain and recall information (for example, words, numbers, pictures, and procedures) after long time periods.	3	5	4
Work Motivation - To take a genuine interest in work tasks; to be willing to go above and beyond normal role duties; to be hard-working and ambitious.	4	4	4
Initiative - To initiate difficult tasks without excessive procrastination; to work independently and accomplish tasks without constant supervision; to take personal responsibility for completing work tasks.	5	3	4
Self-Discipline - To perform difficult, repetitive, or boring tasks while avoiding distractions or alternate activities.	3	5	4
Interpersonal Skills - To get along and interact effectively with a variety of people; to be tactful and diplomatic; to build and maintain effective working relationships with others.	4	4	4

Perceptual Speed and Accuracy - To perceive or compare information (for example, letters, numbers, symbols, or patterns) quickly and accurately; to notice or compare details about things quickly and accurately.	3	5	4
Rule Abiding - To respect authority; to follow instructions and orders; to adhere to military rules, standards, and procedures.	3	5	4
Accountability - To consider oneself responsible for one's actions; to take corrective actions after making a mistake.	4	4	4
Technical Troubleshooting - To use technical information to identify the source of a problem and potential solutions.	3	4	3.5
Navigation Skills - To effectively navigate through an unfamiliar area to a desired location	4	3	3.5
Spatial Visualization - To form a mental image of a pattern or figure; to visualize how an object would look after certain changes are made (for example, when it is moved around or when its parts are rearranged).	3	4	3.5
Achievement Motivation - To seek out difficult and demanding tasks; to show extra effort and persistence when striving to meet work goals; to strive to do the best job possible.	4	3	3.5
Goal Setting - To set and strive towards challenging, realistic work goals; to adjust goals based on performance feedback.	4	3	3.5
Listening Skills - To actively listen to and understand others; to attend to verbal and nonverbal cues (for example, body language, eye contact)	4	3	3.5
Pattern Recognition - To identify or detect a known pattern (for example, a numerical code); to combine and organize different pieces of information into a meaningful pattern quickly.	3	4	3.5
Response Selection - To choose between two or more possible responses quickly and accurately when two or more different signals are given.	3	4	3.5
Reaction Time - To respond quickly and accurately to one signal with a manual (hand or foot) or verbal response.	2	5	3.5
Written Comprehension - To read and understand written English words and sentences.	3	3	3
Written Expression - To write English words or sentences so others will understand; to spell correctly; to write clearly and use language appropriate for the audience.	3	3	3
Adventure Seeking - To prefer tasks that may involve danger or risks (for example, high speeds); to avoid boring or routine activities.	4	2	3
Hearing - To detect and discriminate among sounds that vary in pitch or loudness.	1	5	3

Auditory Attention/Localization - To focus on a sound in the presence of other distracting and irrelevant auditory stimuli; to tell the direction from which a sound came.	3	3	3
Mechanical Comprehension - To understand how machines, tools, and mechanical equipment work; to understand how physical forces affect mechanical components.	2	3	2.5
Integrity - To be honest and trustworthy; to act according to high moral and ethical standards.	3	2	2.5
Energy - To feel excitable and energetic; to show enthusiasm when performing work activities.	3	2	2.5
Color Discrimination - To discriminate between different colors and levels of brightness or shades of the same color.	3	2	2.5
Social Insight - To act appropriately in various social situations; to understand behaviors in the social environment in which they occur.	2	2	2
Agreeableness - To avoid interpersonal conflicts; to reach solutions to problems in a cooperative manner; to avoid upsetting others.	2	2	2
Social Closeness - To maintain close personal relationships; to be sociable and outgoing.	2	2	2
Manual Dexterity - To make skillful, coordinated movements of the hands; to grasp, place, move, or assemble objects using hand movements.	2	2	2
Control Precision - To control the motion of a machine, vehicle, or piece of equipment (for example, joystick or yoke) quickly and accurately; to make fine, precise movements or adjustments.	2	2	2
Multilimb Coordination - To coordinate the movements of the body or limbs.	2	2	2
Hand-eye Coordination - To make precise, coordinated movements based on visual information.	2	2	2
Static Strength – The ability to exert maximum muscle force to lift, push, pull, or carry objects	2	2	2
Explosive Strength – The ability to use short bursts of muscle force to propel oneself (as in jumping or sprinting), or to throw an object	2	2	2
Dynamic Strength – The ability to exert muscle force repeatedly or continuously over time.	2	2	2
Trunk Strength – The ability to use one's abdominal or lower back muscles to support part of the body repeatedly or continuously	2	2	2
Stamina/endurance – The ability to exert oneself physically over long periods of time.	2	2	2
Smell - To identify odors and their possible sources.	1	2	1.5
Touch – To feel heat, vibration, or textures; to feel differences or changes in heat, vibration, or textures.	1	2	1.5

Appendix D. Forward Air Controller/Joint Terminal Attack Controller (FAC/JTAC) Knowledge, Skills, Abilities, and Other Characteristic (KSAO) Ratings

KSAO	Rater 1	Rater 2	Mean rating
Mental Math - To perform mathematical operations in one's head quickly and accurately.	5	5	5
Decision Making Skills - To make effective, confident decisions in a timely manner; to use sound, informed reasoning and avoid bias when making decisions.	5	5	5
Oral Comprehension - To understand spoken English words and sentences (for example, information, ideas, or instructions).	5	5	5
Oral Expression - To speak English words or sentences so others will understand; to express information or ideas clearly.	5	5	5
Spatial Orientation - To know one's location in relation to the environment; to maintain directional orientation when navigating an unfamiliar area; to accurately estimate direction or location after traveling for a certain amount of time.	5	5	5
Map Reading - To understand a visual representation of an area; to use information from a map to aid in navigation.	5	5	5
Concentration/Selective Attention - To maintain high levels of performance on a task in distracting or repetitive conditions; to maintain focus despite interruptions.	5	5	5
Attention Allocation and Control - To flexibly switch attention across different tasks; to attend to multiple, potentially conflicting sources of information.	5	5	5
Task Prioritization - To perform multiple tasks in order of their importance; to direct attention to tasks when they change priorities (e.g., emergencies).	5	5	5
Working Memory - To hold information in memory while processing other information	5	5	5
Teamwork Skills - To coordinate with others in a team setting to accomplish group goals; to assist team members who are overwhelmed; to offer and receive feedback.	5	5	5
Adaptability - To adjust easily to changing situations or unexpected events; to flexibly change one's actions in response to changing task priorities.	5	5	5
Stress Tolerance - To perform effectively under high workload, time pressure, or other stressful situations; to effectively handle stress under demanding situations.	5	5	5
Handling Crisis/Emergency Situations - To remain calm, analyze the situation, act appropriately, and make quick, accurate decisions in emergency situations.	5	5	5

Disengagement - To avoid disruptive thoughts after making an error; to quickly refocus attention on a task after a disturbing situation.	5	5	5
Time Management Skills - To manage one's own time and the time of others to accomplish work goals.	5	5	5
Planning Skills - To carefully plan out the sequence of actions needed to meet short- and long-term work goals.	5	5	5
Visual Acuity - To accurately discriminate details of near or distant objects or objects near the edge of the visual field; to see under low light conditions.	5	5	5
Mathematical Ability - To add, subtract, multiply, and divide accurately.	4	5	4.5
Information Management Skills - To perform research and gather information necessary to solve specific problems; to identify and locate important sources of information (for example, technical manuals).	4	5	4.5
Problem Solving Skills - To recognize problems, their potential causes and solutions, and when they are likely to occur; to create effective and innovative solutions to problems.	4	5	4.5
Mental Rotation - To accurately rotate an object (for example, a map) in one's imagination while maintaining an accurate sense of direction.	5	4	4.5
Listening Skills - To actively listen to and understand others; to attend to verbal and nonverbal cues (for example, body language, eye contact)	4	5	4.5
Emotional Control/Stability - To control one's emotions in stressful situations; to avoid feelings of anxiety, insecurity, depression, or worry.	4	5	4.5
Organization Skills - To schedule and organize one's work activities, materials, tools, and equipment in order to complete tasks efficiently; to keep one's work space neat and tidy.	4	5	4.5
Attention to Detail - To pay close attention to the details of one's work; to ensure work is accurate and complete; to carefully review and scrutinize one's work.	4	5	4.5
Numerical Reasoning - To reason through math problems to determine the operations that can be performed and possible solutions; to apply mathematical formulas to problems.	4	4	4
Systems Comprehension - To understand a system as a whole and the relationships among its components; to anticipate how changes in one component will affect the system as a whole.	3	5	4
Critical Thinking Skills - To analyze the strengths and weaknesses of specific actions or decisions.	4	4	4

Reasoning Skills - To apply rules to come up with logical answers to problems; to combine separate pieces of information to form general rules or conclusions; to recognize patterns or trends and anticipate outcomes.	4	4	4
Confidence - To believe that one is capable of performing tasks in a wide variety of situations; to have confidence in one's skills and abilities.	4	4	4
Dependability - To be responsible, reliable, and punctual; to follow through on commitments.	3	5	4
Self-Discipline - To perform difficult, repetitive, or boring tasks while avoiding distractions or alternate activities.	3	5	4
Accountability - To consider oneself responsible for one's actions; to take corrective actions after making a mistake.	3	5	4
Deliberation - To be careful, thoughtful, and calculating when planning actions; to avoid impulsive actions; to imagine the possible outcomes of one's actions before acting.	3	5	4
Safety Consciousness - To be aware of safety hazards; to take steps to protect oneself and others from harm; to avoid risky behavior that could lead to accidents.	3	5	4
Perceptual Speed and Accuracy - To perceive or compare information (for example, letters, numbers, symbols, or patterns) quickly and accurately; to notice or compare details about things quickly and accurately.	3	5	4
Response Selection - To choose between two or more possible responses quickly and accurately when two or more different signals are given.	3	5	4
Hearing - To detect and discriminate among sounds that vary in pitch or loudness.	3	5	4
Depth Perception - To judge the distance of an object from an observer; to judge the relative distance of multiple objects from an observer.	3	5	4
Technical Troubleshooting - To use technical information to identify the source of a problem and potential solutions.	3	4	3.5
Navigation Skills - To effectively navigate through an unfamiliar area to a desired location	4	3	3.5
Spatial Visualization - To form a mental image of a pattern or figure; to visualize how an object would look after certain changes are made (for example, when it is moved around or when its parts are rearranged).	3	4	3.5
Learning Ability - To be willing and able to acquire new skills quickly and easily; to quickly understand new concepts, ideas, or facts.	4	3	3.5

Long-term Memory - To retain and recall information (for example, words, numbers, pictures, and procedures) after long time periods.	3	4	3.5
Initiative - To initiate difficult tasks without excessive procrastination; to work independently and accomplish tasks without constant supervision; to take personal responsibility for completing work tasks.	4	3	3.5
Mastery Orientation - To seek out opportunities to acquire new skills and knowledge; to seek and use feedback to improve performance; to view performance errors as opportunities for self-improvement.	3	4	3.5
Rule Abiding - To respect authority; to follow instructions and orders; to adhere to military rules, standards, and procedures.	3	4	3.5
Interpersonal Skills - To get along and interact effectively with a variety of people; to be tactful and diplomatic; to build and maintain effective working relationships with others.	4	3	3.5
Leadership Skills - To persuade and influence others to do perform specific actions; to act as a role model for others; to offer instruction and feedback to others as part of a team.	3	4	3.5
Leadership Motivation - To be motivated to assume leadership roles and responsibilities, and to maintain such motivation in persistence and intensity over time	3	4	3.5
Assertiveness - To take charge and make decisions; to be persuasive, influential, and direct when dealing with others	4	3	3.5
Pattern Recognition - To identify or detect a known pattern (for example, a numerical code); to combine and organize different pieces of information into a meaningful pattern quickly.	3	4	3.5
Reaction Time - To respond quickly and accurately to one signal with a manual (hand or foot) or verbal response.	2	5	3.5
Work Motivation - To take a genuine interest in work tasks; to be willing to go above and beyond normal role duties; to be hard-working and ambitious.	3	3	3
Achievement Motivation - To seek out difficult and demanding tasks; to show extra effort and persistence when striving to meet work goals; to strive to do the best job possible.	3	3	3
Goal Setting - To set and strive towards challenging, realistic work goals; to adjust goals based on performance feedback.	3	3	3
Integrity - To be honest and trustworthy; to act according to high moral and ethical standards.	3	3	3
Social Insight - To act appropriately in various social situations; to understand behaviors in the social environment in which they occur.	3	3	3
Energy - To feel excitable and energetic; to show enthusiasm when performing work activities.	2	4	3

Color Discrimination - To discriminate between different colors and levels of brightness or shades of the same color.	3	3	3
Auditory Attention/Localization - To focus on a sound in the presence of other distracting and irrelevant auditory stimuli; to tell the direction from which a sound came.	2	4	3
Written Comprehension - To read and understand written English words and sentences.	3	2	2.5
Agreeableness - To avoid interpersonal conflicts; to reach solutions to problems in a cooperative manner; to avoid upsetting others.	2	3	2.5
Social Closeness - To maintain close personal relationships; to be sociable and outgoing.	2	3	2.5
Control Precision - To control the motion of a machine, vehicle, or piece of equipment (for example, joystick or yoke) quickly and accurately; to make fine, precise movements or adjustments.	2	3	2.5
Manual Dexterity - To make skillful, coordinated movements of the hands; to grasp, place, move, or assemble objects using hand movements.	3	2	2.5
Hand-eye Coordination - To make precise, coordinated movements based on visual information.	3	2	2.5
Stamina/endurance – The ability to exert oneself physically over long periods of time.	2	3	2.5
Written Expression - To write English words or sentences so others will understand; to spell correctly; to write clearly and use language appropriate for the audience.	2	2	2
Mechanical Comprehension - To understand how machines, tools, and mechanical equipment work; to understand how physical forces affect mechanical components.	2	2	2
Adventure Seeking - To prefer tasks that may involve danger or risks (for example, high speeds); to avoid boring or routine activities.	2	2	2
Static Strength – The ability to exert maximum muscle force to lift, push, pull, or carry objects	2	2	2
Explosive Strength – The ability to use short bursts of muscle force to propel oneself (as in jumping or sprinting), or to throw an object	2	2	2
Dynamic Strength – The ability to exert muscle force repeatedly or continuously over time.	2	2	2
Trunk Strength – The ability to use one's abdominal or lower back muscles to support part of the body repeatedly or continuously	2	2	2
Smell - To identify odors and their possible sources.	1	2	1.5
Touch – To feel heat, vibration, or textures; to feel differences or changes in heat, vibration, or textures.	1	2	1.5
Multilimb Coordination - To coordinate the movements of the body.	1	2	1.5

Appendix E. Forward Observer (FO) Knowledge, Skills, Abilities, and Other Characteristic (KSAO) Ratings

KSAO	Rater 1	Rater 2	Mean rating
Mental Math - To perform mathematical operations in one's head quickly and accurately.	5	5	5
Oral Comprehension - To understand spoken English words and sentences (for example, information, ideas, or instructions).	5	5	5
Oral Expression - To speak English words or sentences so others will understand; to express information or ideas clearly.	5	5	5
Spatial Orientation - To know one's location in relation to the environment; to maintain directional orientation when navigating an unfamiliar area; to accurately estimate direction or location after traveling for a certain amount of time.	5	5	5
Map Reading - To understand a visual representation of an area; to use information from a map to aid in navigation.	5	5	5
Concentration/Selective Attention - To maintain high levels of performance on a task in distracting or repetitive conditions; to maintain focus despite interruptions.	5	5	5
Attention Allocation and Control - To flexibly switch attention across different tasks; to attend to multiple, potentially conflicting sources of information.	5	5	5
Task Prioritization - To perform multiple tasks in order of their importance; to direct attention to tasks when they change priorities (e.g., emergencies).	5	5	5
Working Memory - To hold information in memory while processing other information	5	5	5
Teamwork Skills - To coordinate with others in a team setting to accomplish group goals; to assist team members who are overwhelmed; to offer and receive feedback.	5	5	5
Adaptability - To adjust easily to changing situations or unexpected events; to flexibly change one's actions in response to changing task priorities.	5	5	5
Emotional Control/Stability - To control one's emotions in stressful situations; to avoid feelings of anxiety, insecurity, depression, or worry.	5	5	5
Stress Tolerance - To perform effectively under high workload, time pressure, or other stressful situations; to effectively handle stress under demanding situations.	5	5	5
Handling Crisis/Emergency Situations - To remain calm, analyze the situation, act appropriately, and make quick, accurate decisions in emergency situations.	5	5	5

Disengagement - To avoid disruptive thoughts after making an error; to quickly refocus attention on a task after a disturbing situation.	5	5	5
Planning Skills - To carefully plan out the sequence of actions needed to meet short- and long-term work goals.	5	5	5
Attention to Detail - To pay close attention to the details of one's work; to ensure work is accurate and complete; to carefully review and scrutinize one's work.	5	5	5
Visual Acuity - To accurately discriminate details of near or distant objects or objects near the edge of the visual field; to see under low light conditions.	5	5	5
Depth Perception - To judge the distance of an object from an observer; to judge the relative distance of multiple objects from an observer.	5	5	5
Numerical Reasoning - To reason through math problems to determine the operations that can be performed and possible solutions; to apply mathematical formulas to problems.	4	5	4.5
Information Management Skills - To perform research and gather information necessary to solve specific problems; to identify and locate important sources of information (for example, technical manuals).	4	5	4.5
Critical Thinking Skills - To analyze the strengths and weaknesses of specific actions or decisions.	5	4	4.5
Problem Solving Skills - To recognize problems, their potential causes and solutions, and when they are likely to occur; to create effective and innovative solutions to problems.	5	4	4.5
Decision Making Skills - To make effective, confident decisions in a timely manner; to use sound, informed reasoning and avoid bias when making decisions.	4	5	4.5
Mental Rotation - To accurately rotate an object (for example, a map) in one's imagination while maintaining an accurate sense of direction.	4	5	4.5
Accountability - To consider oneself responsible for one's actions; to take corrective actions after making a mistake.	4	5	4.5
Deliberation - To be careful, thoughtful, and calculating when planning actions; to avoid impulsive actions; to imagine the possible outcomes of one's actions before acting.	4	5	4.5
Listening Skills - To actively listen to and understand others; to attend to verbal and nonverbal cues (for example, body language, eye contact)	5	4	4.5
Organization Skills - To schedule and organize one's work activities, materials, tools, and equipment in order to complete tasks efficiently; to keep one's work space neat and tidy.	4	5	4.5

Time Management Skills - To manage one's own time and the time of others to accomplish work goals.	4	5	4.5
Mathematical Ability - To add, subtract, multiply, and divide accurately.	4	4	4
Reasoning Skills - To apply rules to come up with logical answers to problems; to combine separate pieces of information to form general rules or conclusions; to recognize patterns or trends and anticipate outcomes.	4	4	4
Initiative - To initiate difficult tasks without excessive procrastination; to work independently and accomplish tasks without constant supervision; to take personal responsibility for completing work tasks.	5	3	4
Confidence - To believe that one is capable of performing tasks in a wide variety of situations; to have confidence in one's skills and abilities.	4	4	4
Dependability - To be responsible, reliable, and punctual; to follow through on commitments.	3	5	4
Self-Discipline - To perform difficult, repetitive, or boring tasks while avoiding distractions or alternate activities.	3	5	4
Safety Consciousness - To be aware of safety hazards; to take steps to protect oneself and others from harm; to avoid risky behavior that could lead to accidents.	3	5	4
Perceptual Speed and Accuracy - To perceive or compare information (for example, letters, numbers, symbols, or patterns) quickly and accurately; to notice or compare details about things quickly and accurately.	3	5	4
Response Selection - To choose between two or more possible responses quickly and accurately when two or more different signals are given.	3	5	4
Technical Troubleshooting - To use technical information to identify the source of a problem and potential solutions.	3	4	3.5
Navigation Skills - To effectively navigate through an unfamiliar area to a desired location	4	3	3.5
Spatial Visualization - To form a mental image of a pattern or figure; to visualize how an object would look after certain changes are made (for example, when it is moved around or when its parts are rearranged).	3	4	3.5
Learning Ability - To be willing and able to acquire new skills quickly and easily; to quickly understand new concepts, ideas, or facts.	3	4	3.5
Long-term Memory - To retain and recall information (for example, words, numbers, pictures, and procedures) after long time periods.	3	4	3.5
Work Motivation - To take a genuine interest in work tasks; to be willing to go above and beyond normal role duties; to be hard-working and ambitious.	4	3	3.5

Mastery Orientation - To seek out opportunities to acquire new skills and knowledge; to seek and use feedback to improve performance; to view performance errors as opportunities for self-improvement.	3	4	3.5
Leadership Skills - To persuade and influence others to do perform specific actions; to act as a role model for others; to offer instruction and feedback to others as part of a team.	4	3	3.5
Assertiveness - To take charge and make decisions; to be persuasive, influential, and direct when dealing with others	5	2	3.5
Pattern Recognition - To identify or detect a known pattern (for example, a numerical code); to combine and organize different pieces of information into a meaningful pattern quickly.	3	4	3.5
Control Precision - To control the motion of a machine, vehicle, or piece of equipment (for example, joystick or yoke) quickly and accurately; to make fine, precise movements or adjustments.	4	3	3.5
Reaction Time - To respond quickly and accurately to one signal with a manual (hand or foot) or verbal response.	2	5	3.5
Stamina/endurance – The ability to exert oneself physically over long periods of time.	3	4	3.5
Systems Comprehension - To understand a system as a whole and the relationships among its components; to anticipate how changes in one component will affect the system as a whole.	3	3	3
Written Comprehension - To read and understand written English words and sentences.	3	3	3
Mechanical Comprehension - To understand how machines, tools, and mechanical equipment work; to understand how physical forces affect mechanical components.	2	4	3
Achievement Motivation - To seek out difficult and demanding tasks; to show extra effort and persistence when striving to meet work goals; to strive to do the best job possible.	3	3	3
Rule Abiding - To respect authority; to follow instructions and orders; to adhere to military rules, standards, and procedures.	3	3	3
Integrity - To be honest and trustworthy; to act according to high moral and ethical standards.	3	3	3
Interpersonal Skills - To get along and interact effectively with a variety of people; to be tactful and diplomatic; to build and maintain effective working relationships with others.	3	3	3
Energy - To feel excitable and energetic; to show enthusiasm when performing work activities.	3	3	3
Adventure Seeking - To prefer tasks that may involve danger or risks (for example, high speeds); to avoid boring or routine activities.	3	3	3

Hearing - To detect and discriminate among sounds that vary in pitch or loudness.	3	3	3
Color Discrimination - To discriminate between different colors and levels of brightness or shades of the same color.	3	3	3
Manual Dexterity - To make skillful, coordinated movements of the hands; to grasp, place, move, or assemble objects using hand movements.	3	3	3
Hand-eye Coordination - To make precise, coordinated movements based on visual information.	3	3	3
Goal Setting - To set and strive towards challenging, realistic work goals; to adjust goals based on performance feedback.	2	3	2.5
Social Insight - To act appropriately in various social situations; to understand behaviors in the social environment in which they occur.	2	3	2.5
Agreeableness - To avoid interpersonal conflicts; to reach solutions to problems in a cooperative manner; to avoid upsetting others.	2	3	2.5
Social Closeness - To maintain close personal relationships; to be sociable and outgoing.	2	3	2.5
Leadership Motivation - To be motivated to assume leadership roles and responsibilities, and to maintain such motivation in persistence and intensity over time	2	3	2.5
Auditory Attention/Localization - To focus on a sound in the presence of other distracting and irrelevant auditory stimuli; to tell the direction from which a sound came.	2	3	2.5
Written Expression - To write English words or sentences so others will understand; to spell correctly; to write clearly and use language appropriate for the audience.	2	2	2
Smell - To identify odors and their possible sources.	1	3	2
Touch - To feel heat, vibration, or textures; to feel differences or changes in heat, vibration, or textures.	1	3	2
Multilimb Coordination - To coordinate the movements of the body or limbs.	2	2	2
Static Strength – The ability to exert maximum muscle force to lift, push, pull, or carry objects	2	2	2
Explosive Strength – The ability to use short bursts of muscle force to propel oneself (as in jumping or sprinting), or to throw an object	2	2	2
Dynamic Strength – The ability to exert muscle force repeatedly or continuously over time.	2	2	2
Trunk Strength – The ability to use one's abdominal or lower back muscles to support part of the body repeatedly or continuously	2	2	2